v2.6 RTMA/URMA and Rapid Update RTMA Science Briefing

Manuel Pondeca, Steven Levine, Runhua Yang, Ying Lin, Jacob Carley, Stylianos Flampouris, Henrique Alves, Jeff Whiting, Shelley Melchior, Annette Gibbs, George Gayno, Jim Purser, Ting Lei, Wan-Shu Wu, David Parrish, Ben Blake, Corey Guastini, Geoff Manikin, and John Derber

June 26th, 2017

Quick update on "Good enough" items

Task Tracking Document Here

- Developed in consultation with EMC management

- This goes over the issues described by the 'RTMA Good Enough Group' led by Dave Bernhardt et al.

- Entries worked on in v2.6 and/or upcoming implementations in support of RTMA:

    - Item 2e: Relaxation of gross error check tolerances to allow use of more observations

    - Item 2b: Simplified updating of reject lists through Obs Processing change: expanded to include mesonets

        - Awaiting NCO implementation of RFC to get into production (see back-up slides)

- Entries worked on (and still being worked on) and anticipated for v2.7:

    - Item 3a/d: Much expanded ability for different weighting for different observations in varied situations.

v2.6 Bundle: Timeline

- Note* This is the first RTMA/URMA upgrade under the new procedures, means the evaluation occurs before hand off to NCO for their 30 IT day test
  - EMC devs conduct and run all pre-implementation testing.
  - Need to have continued discussions with user community to consider other ways to facilitate evals (e.g. retrospectives).
- Implementation scheduled for October.

v2.6 Bundle: Contents + Outline

- Rapid Update RTMA (15-minute cycle) - support AWC, HEMS, and aviation users

- Hourly precip URMA for ConUS and Puerto Rico - support NBM

- New terrain and land/sea mask in use for CONUS/PR/HI
  - AK files to come in 2.7
- New output fields:
  - min/max RH product (URMA) - support NBM
  - Significant wave height analysis (URMA) - support NBM and coastal WFOs

v2.6 Bundle: Contents + Outline

- Relax QC criteria to increase use of mesonet temperature and moisture data
  - Assists with good enough item 2e
- New obs for URMA
  - Pseudo obs over Great Lakes via GLERL adjustment (long awaited item)
  - New data from UrbaNet and COOP
- Bug fix: Ceiling background from downscaled RAP/HRRR
- Reduce steepening in background error model along land/water boundaries based upon forecaster feedback

v2.6 Bundle: Rapid Update RTMA

- RTMA system with updates every 15 minutes instead of every hour

- Focus is aviation applications

  - Helicopter Emergency Med. Services tool

  - Collaborative FAA AWRP project with AWC

- Uses closest in time available data for C&V

  - No time interpolation among a window of observations

  - Closer fit to data

  - Uses 15 min output from HRRR

RURTMA Ceiling
20170604 1030Z cycle F00 mins Valid 20170604 1030Z

Hundreds of feet (AGL)

Observations
1030Z

Hundreds of feet (AGL)
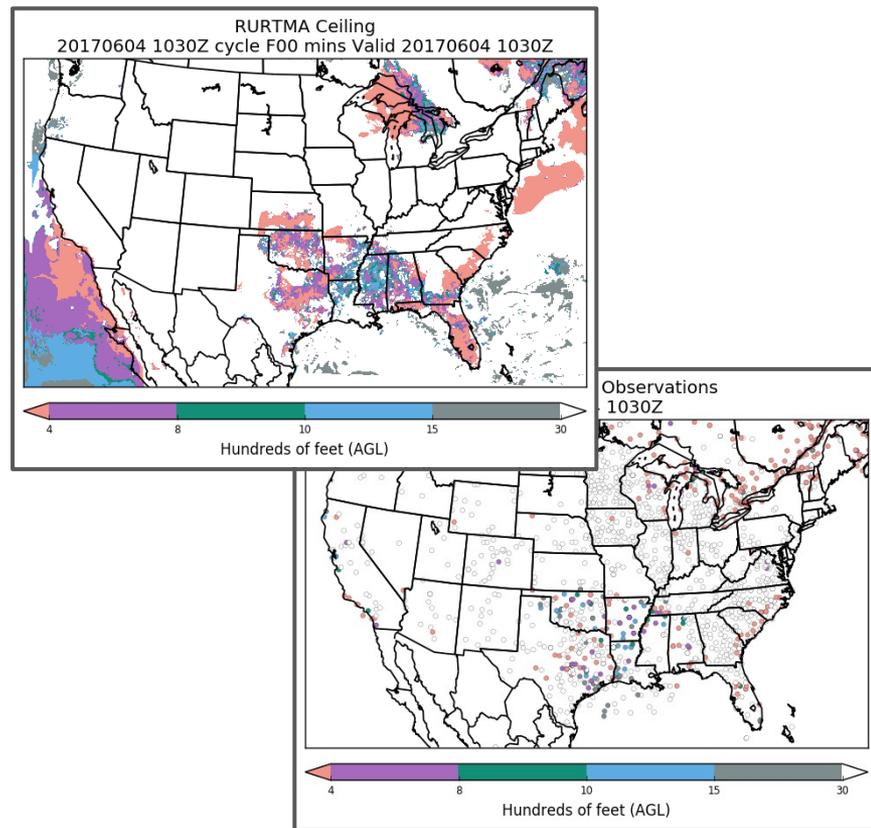
v2.6 Bundle: Rapid Update RTMA
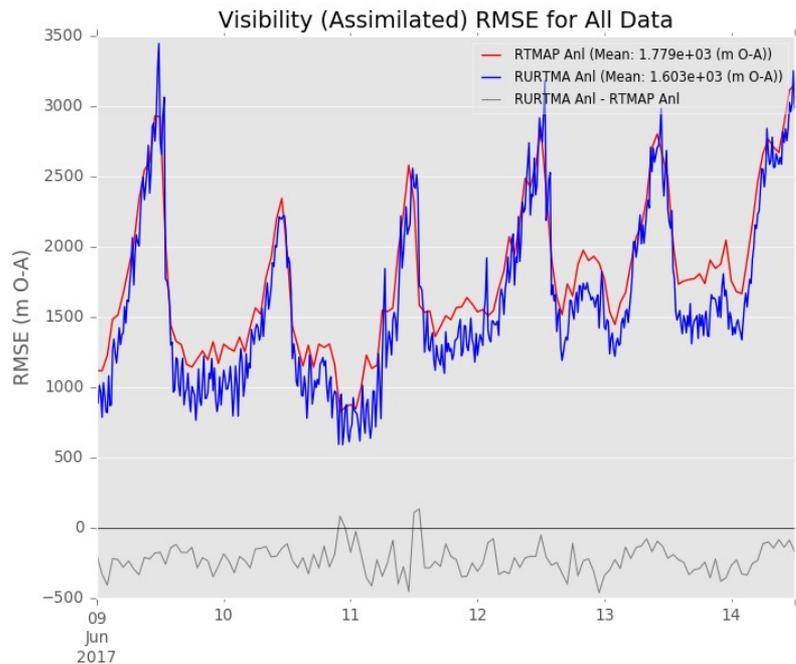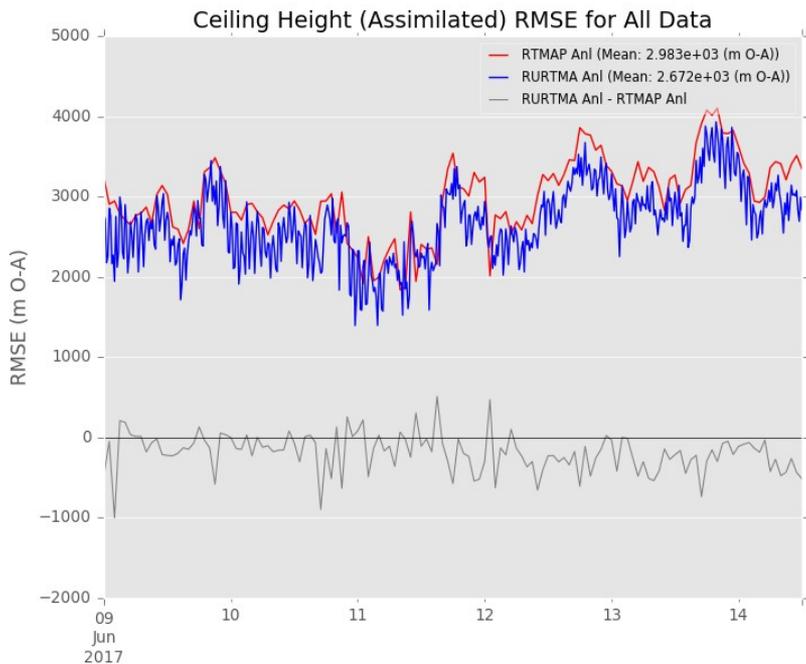
RURTMA (blue) fits ceiling and vis data more closely than hourly v2.6 RTMA (red)
- For C&V RU-RTMA only uses the observation closest to the analysis time

v2.6 Bundle: Rapid Update RTMA
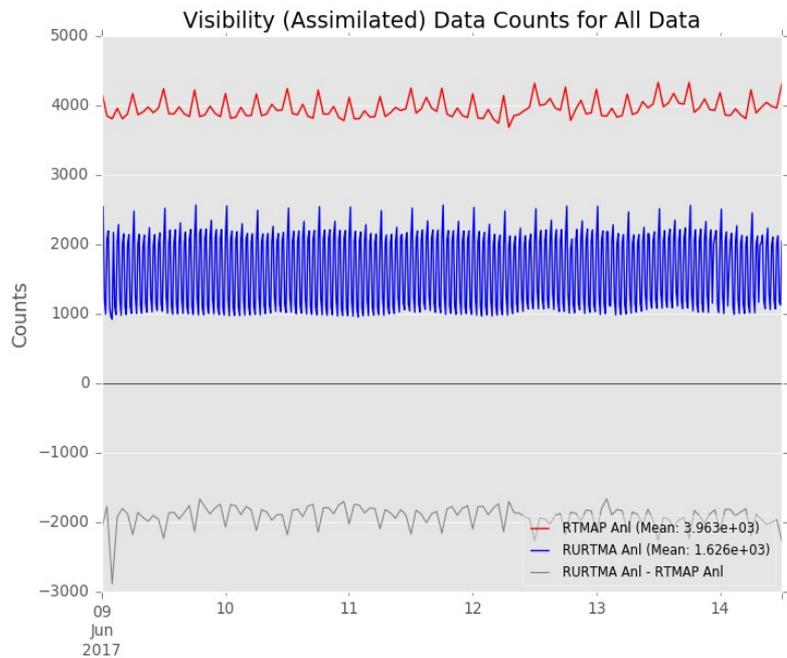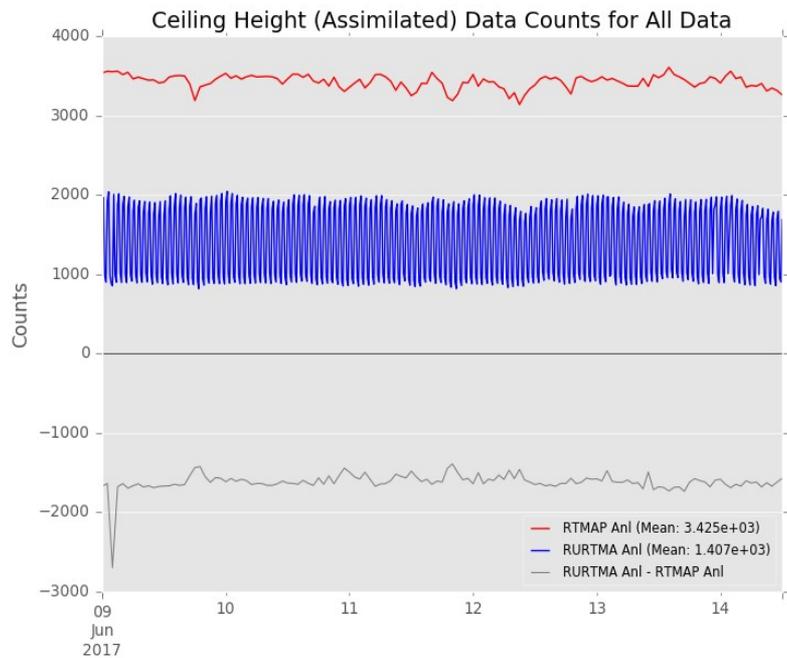
RURTMA (blue) uses less data *per cycle* than hourly v2.6 RTMA (red)
- The number of assimilated obs for each 15-min window is less than hourly v2.6 RTMA.
- BUT the sum of assimilated obs in RURTMA in one hour is, on average, more than that in the hourly v2.6 RTMA

v2.6 Bundle: Precipitation URMA

- **Currently in operation:** 6-hourly URMA for ConUS, Alaska and Puerto Rico (from hourly/6h RFC QPEs)

- **v2.6:** add hourly ConUS and PR URMA - supports the NBM

  - **PR:** SERFC produces hourly and 6h QPEs for Puerto Rico

  - **Issue for ConUS hourly:** NWRFC and CNRFC only have 6h QPEs, the other 10 ConUS RFCs produce hourly QPEs. MRMS has hourly QPEs, but in the complex terrain out West the gauge-based RFC QPEs often has an advantage over the MRMS.

  - **Solution:** time-disaggregate 6h QPEs from NWRFC/CNRFC into hourly QPEs using hourly gauge-corrected MRMS as weights (if MRMS is missing or has zero precip in an area for the entire 6h, weight for each hour is assumed to be ⅙), and combine these with the hourly QPEs from the 10 other RFCs for a ConUS mosaic.

  - Kick off precip RTMA/URMA processing from pcpanl package (separate out precip RTMA/URMA from Stage II/IV processing)

v2.6 Bundle: Precipitation URMA

24h totals ending 12Z 7 Apr 2017
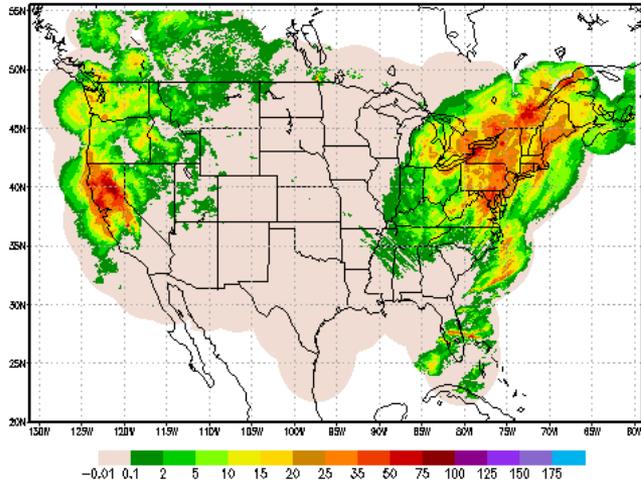
MRMS
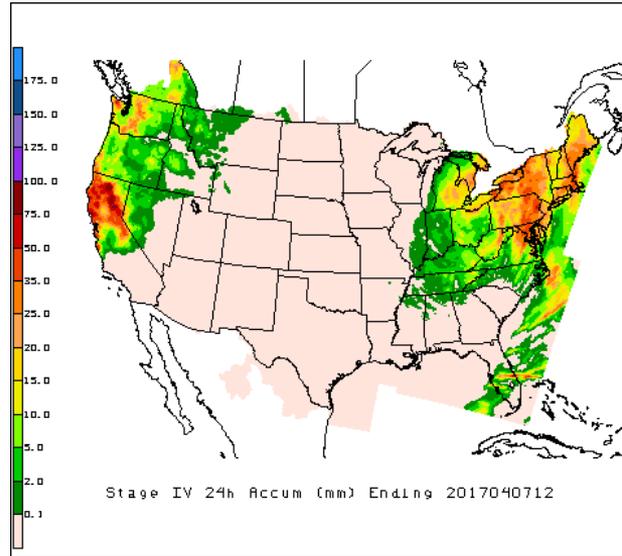
Stage IV
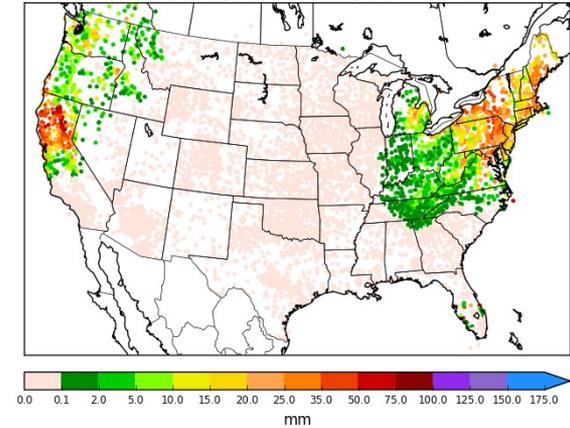
QC'd Daily Gauges

# v2.6 Bundle: Precipitation URMA

1h ending 07Z 20140411
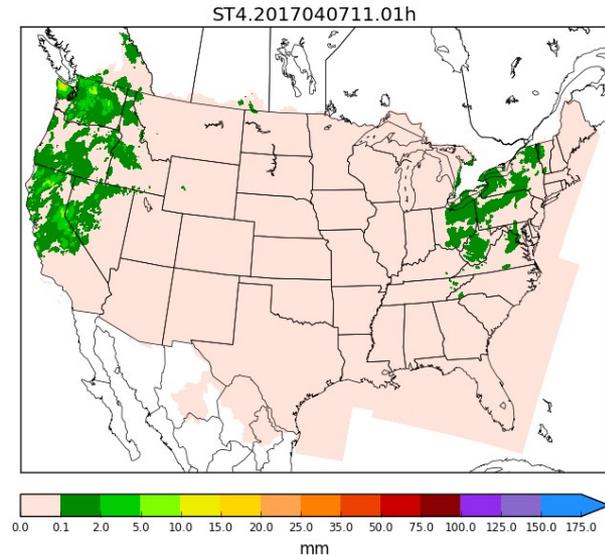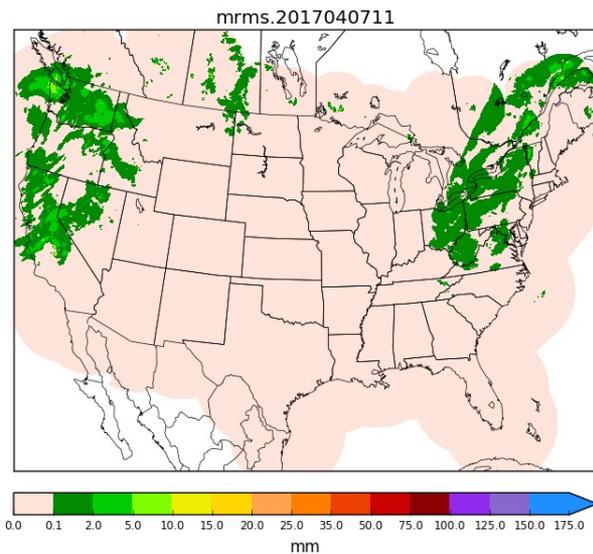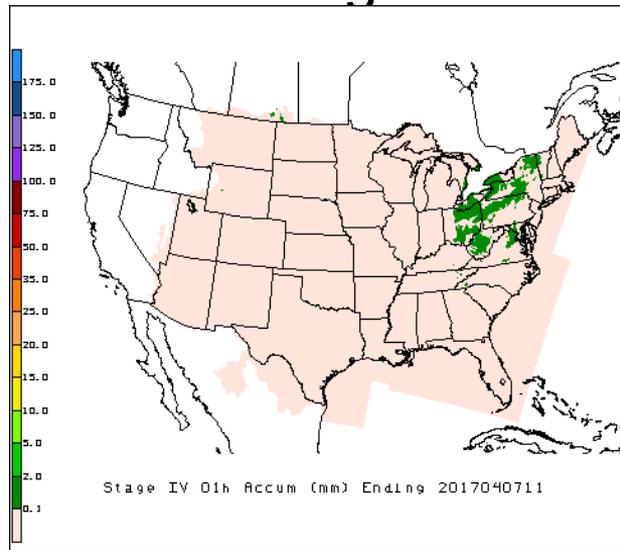
Current Hourly Stage IV (mosaic of RFC QPE): no coverage in NWRFC and CNRFC areas

Hourly MRMS

V2.6: hourly Stage IV/URMA

** Note: NWRFC/CNRFC have no offshore coverage
  ➔ Plan to fill in gaps with MRMS and/or satellite data in RTMA/URMA v2.7.

Stage IV to become source for water.weather.gov/precip
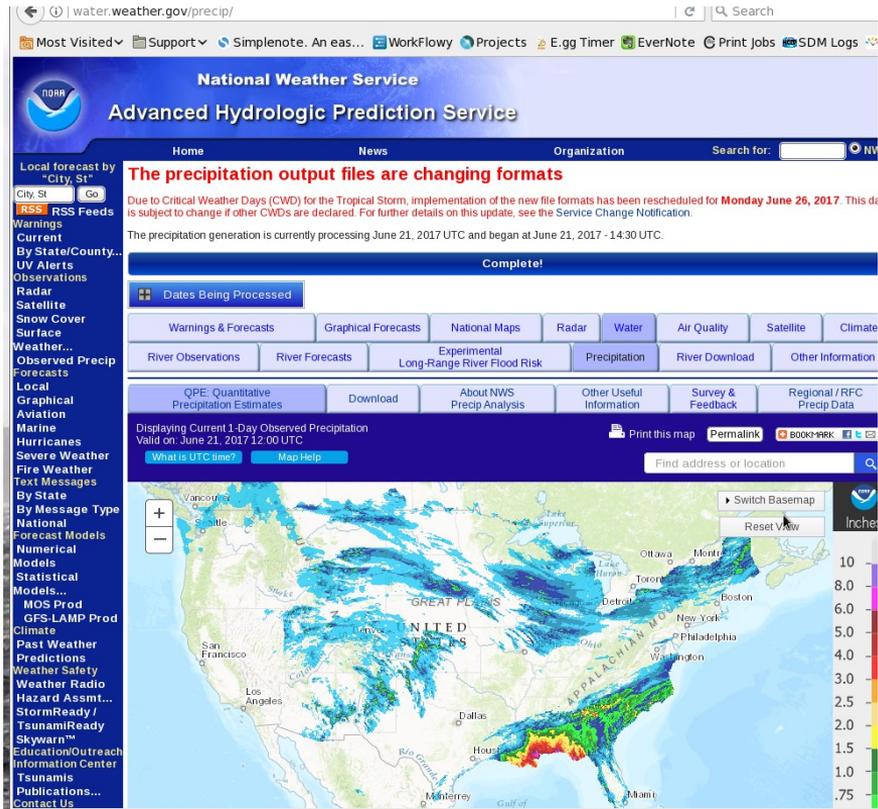

AHPS will switch to using NCEP Stage IV the week of 26 June (some minor changes in Stage IV processing for RTMA/URMA v2.5 was to accommodate its usage in water.weather.gov/precip)

v2.6 Bundle: New terrain and land/sea mask

For CONUS/PR/HI

- AK files to come in 2.7
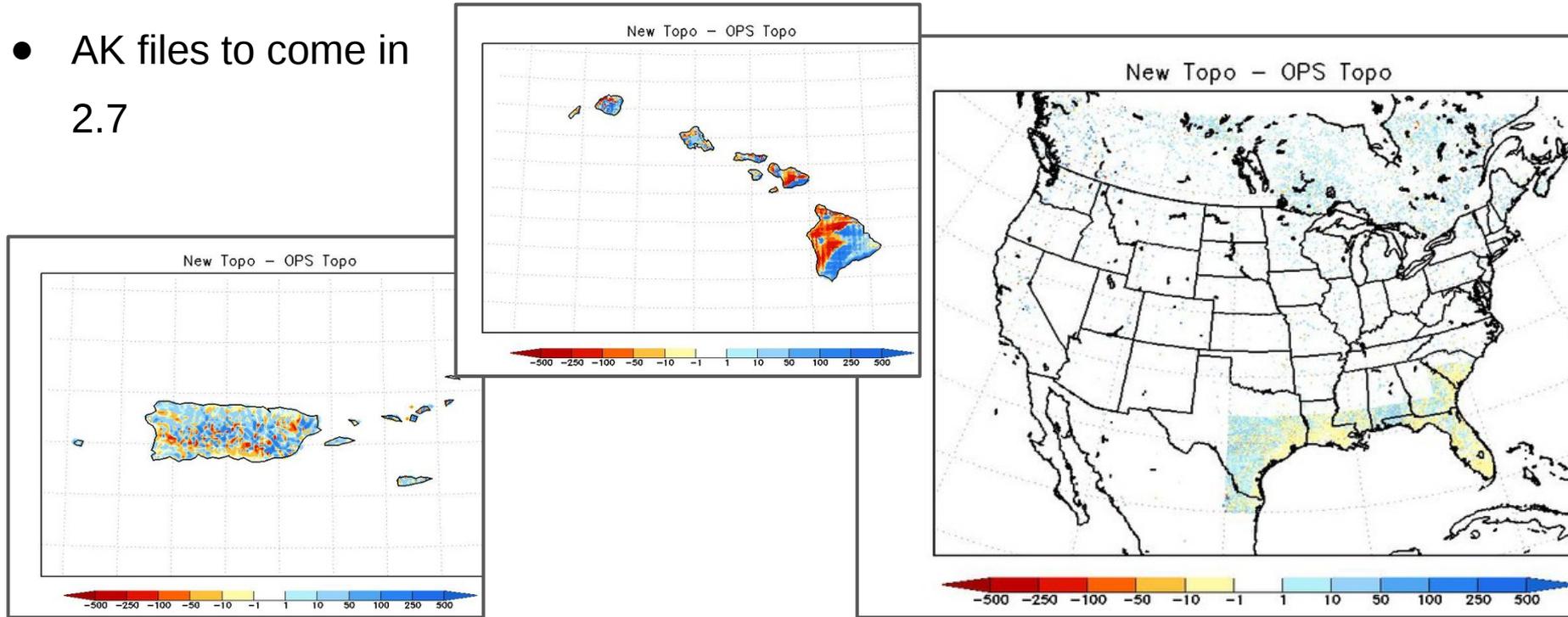
Thanks to Geoff Wagner, Brian Miretzky, George Gayno, WFOs, Regions, and others for all the help!

v2.6 Bundle: Min/Max RH

- Requested by NBM/MDL

- Maximum of hourly RH values from previous 12 hourly URMAs
  - RH derived from temperature and dew point analyses

- MaxRH: 06-18Z, minRH: 18-06Z
  - For CONUS, AK, HI and PR domains
  - No local time zone adjustment
  - Co-indices with min/max T analyses
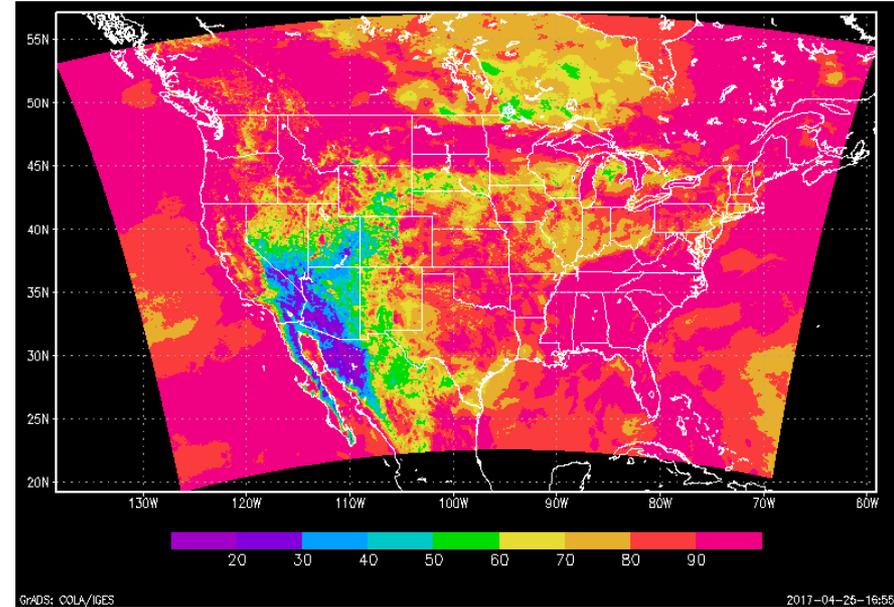
CONUS maxRH (%) valid 4/24/17

V2.6 Bundle: URMA Significant Wave Height

Background is from Global WW3
Assimilates buoy and satellite
   altimeter observations
      Satellite data:
         ~650 Obs per hour
         Jason-3, Saral/Altika and
         CryoSat-2
      In-situ buoy data:
         ~60 obs per hour

URMAP_ANL Hs
20170615 03Z cycle F00 hrs Valid 20170615 03Z
Analysis

URMAP_GES Hs
20170615 02Z cycle F01 hrs Valid 20170615 03Z
Background

URMAP Hs Analysis Increments
Valid 20170615 03Z
Increments

URMAP Hs Observations
Valid 20170615 03Z
Observations
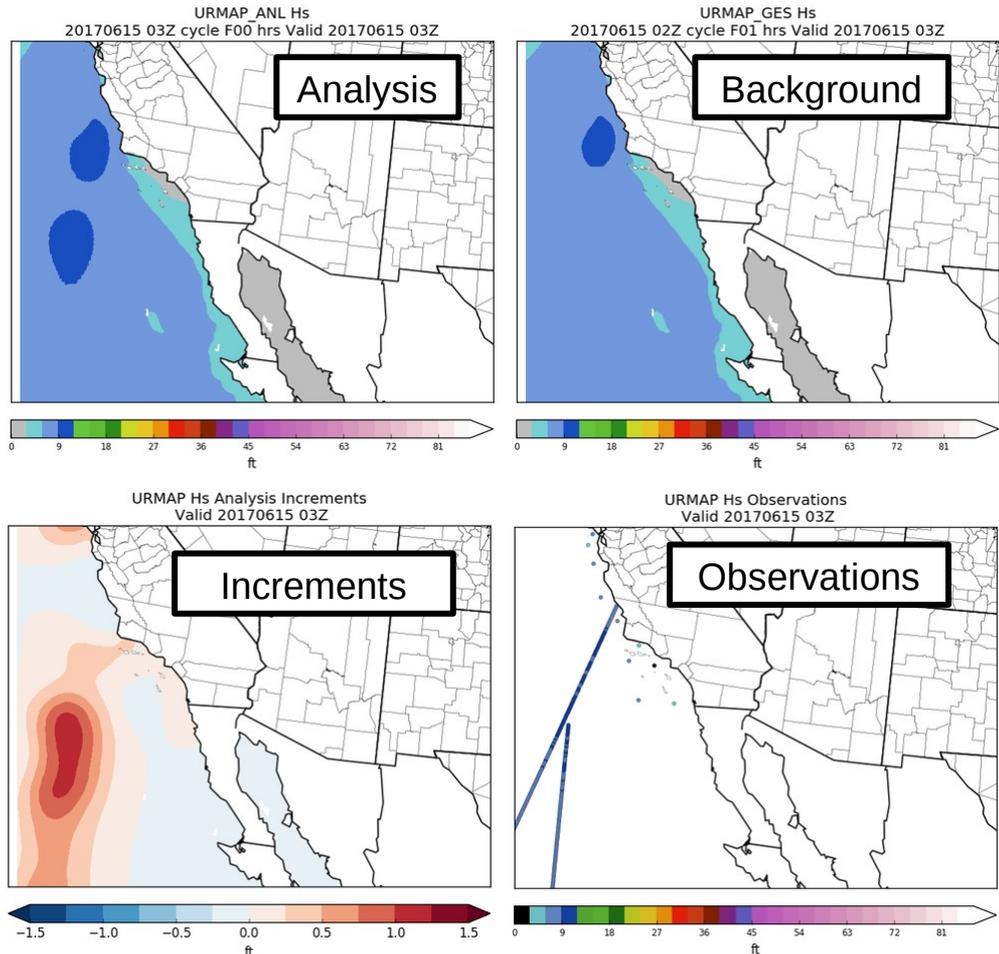
v2.6 Bundle: Significant Wave Height Analysis

RMSE

Significant Wave Height (Assimilated) RMSE for All Data

URMAP Ges (Mean: 2.630e-01 (m))
URMAP Anl (Mean: 1.925e-01 (m))
URMAP Anl - URMAP Ges

URMA Guess
URMA Analysis

Counts

Significant Wave Height (Assimilated) Data Counts for All Data

URMAP Ges (Mean: 6.029e+02)
URMAP Anl (Mean: 6.136e+02)
URMAP Anl - URMAP Ges

Bias (O-F)

Significant Wave Height (Assimilated) Bias for All Data
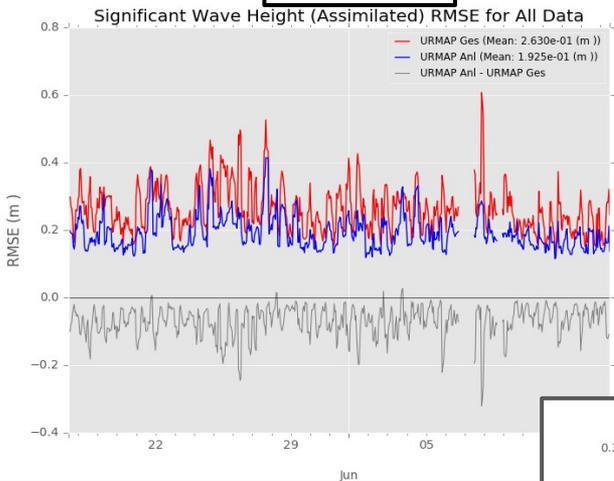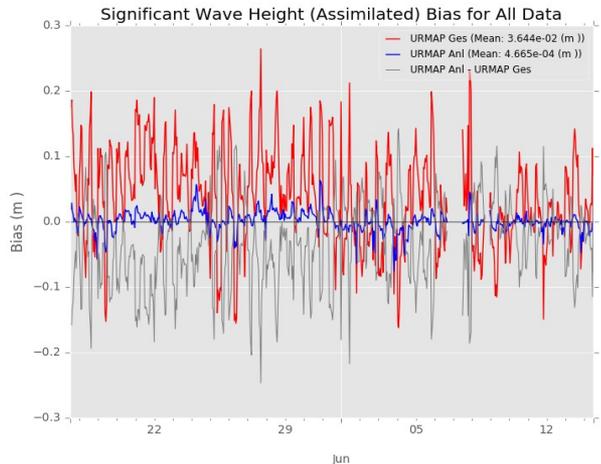
URMAP Ges (Mean: 3.644e-02 (m))
URMAP Anl (Mean: 4.665e-04 (m))
URMAP Anl - URMAP Ges
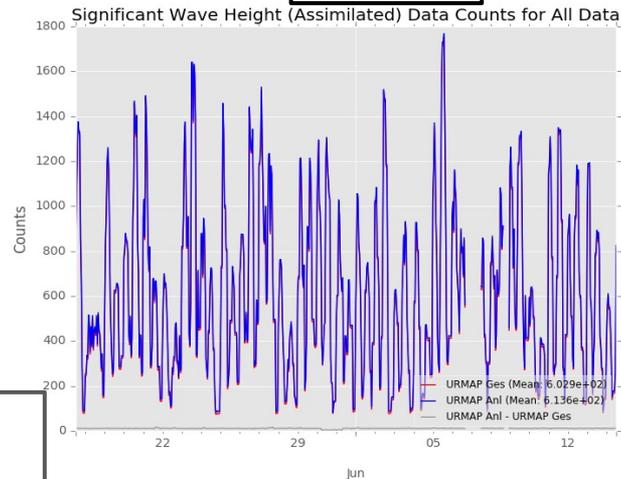
v2.6 Bundle: Adding ceiling to Alaska

RMSE

Ceiling Height (Assimilated) RMSE for All Data

URMA Guess
URMA Analysis

Counts

Ceiling Height (Assimilated) Data Counts for All Data

Bias (O-F)

Ceiling Height (Assimilated) Bias for All Data
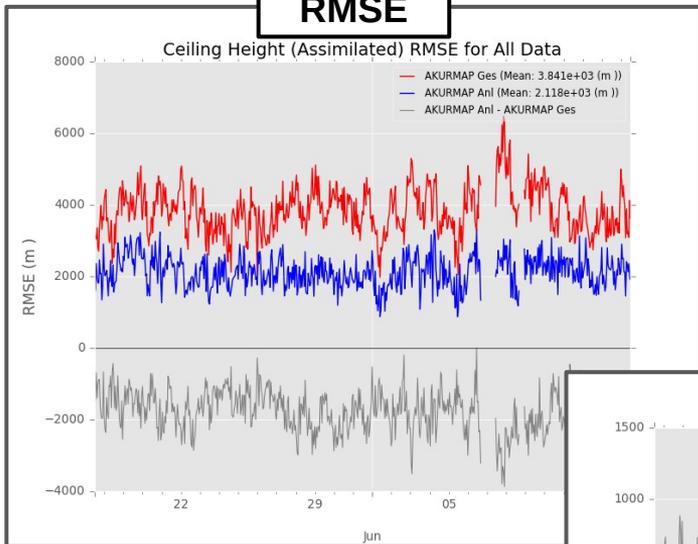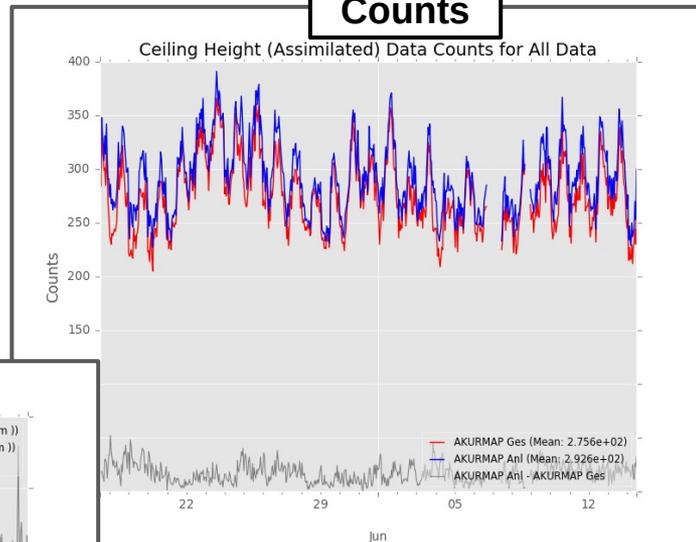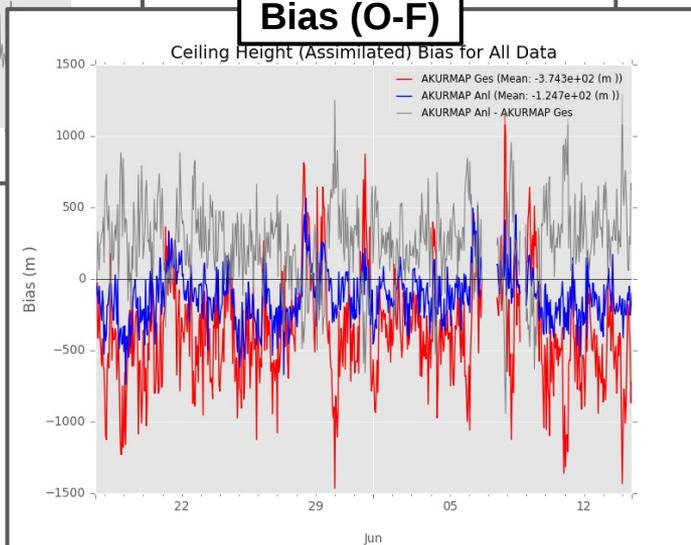
250-300 obs per analysis

# v2.6: Relax Gross Error QC for Mesonet T and Q data

- Relaxed by 10%
  - Help address 'Good Enough' item 2e
  - Why?
    - During the iterative analysis procedure more mesonet T and Q observations would trickle in as the background adjusted to the analysis
    - Implies we are too strict with the gross error QC for these ob types
  - What does this mean?
    - We assimilate more observations
    - Those additional observations have a <u>larger deviation from the background</u>
      - As a result, bulk stats will show a slightly larger RMSE
  - For CONUS RTMA:
    - About 200-300 additional T and Q obs per analysis
    - Mostly stations with multiple reports
  - Applied to all domains

v2.6: Relax Gross Error QC for Mesonet T and Q data

Additional stations allowed in over a 24 hour period ending 06Z June 22, 2017

*Stations may have multiple reports/observations
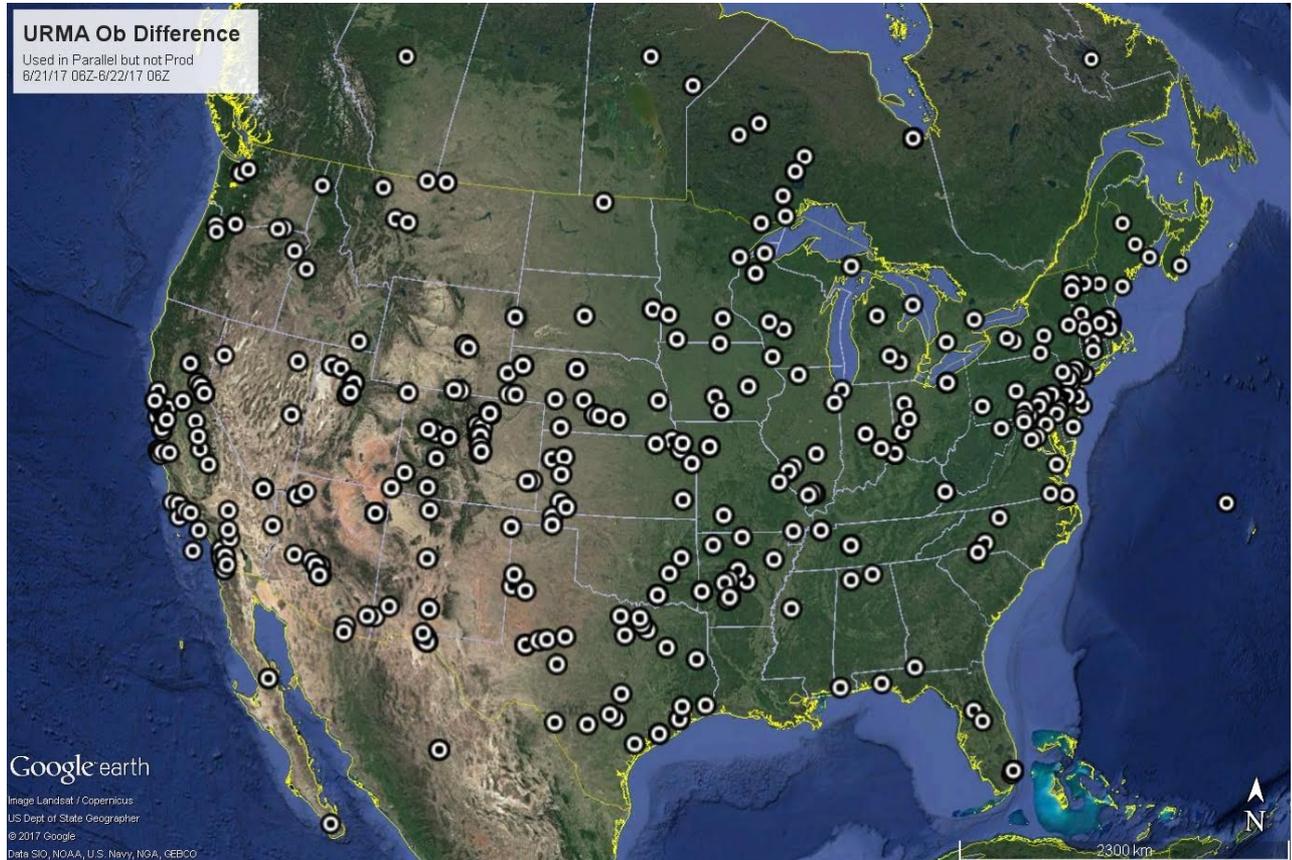
v2.6 Bundle: New UrbaNet Observation Locations (URMA)

UrbaNet Sites
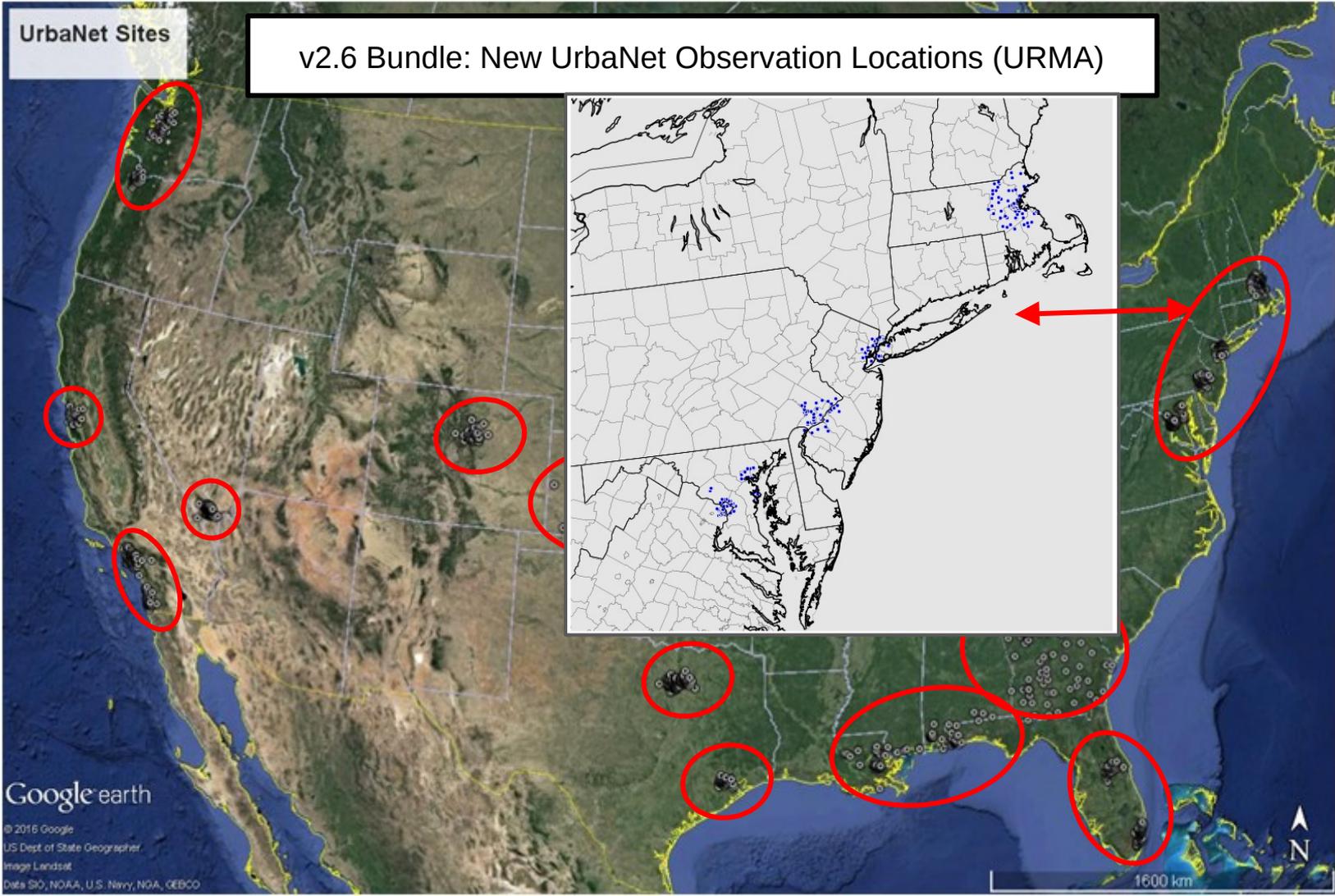
v2.6: New data and relaxed gross error QC impacts

- ~11 thousand new T and Q obs per URMA analysis

- ~ 5 thousand new wind obs per analysis

- Very small increase in analysis RMSE due to relaxed gross error QC

  - Larger O-Fs allowed into analysis translates to having larger O-As in the analysis

  - ~0.02 K for T and and Min/Max T

  - ~0.04 g/kg for specific humidity

2m T Counts

2m T RMSE
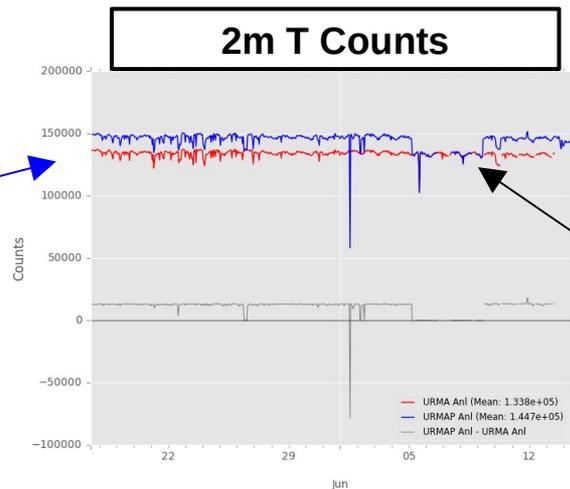
WCOSS prod switches/downtime - used prod data
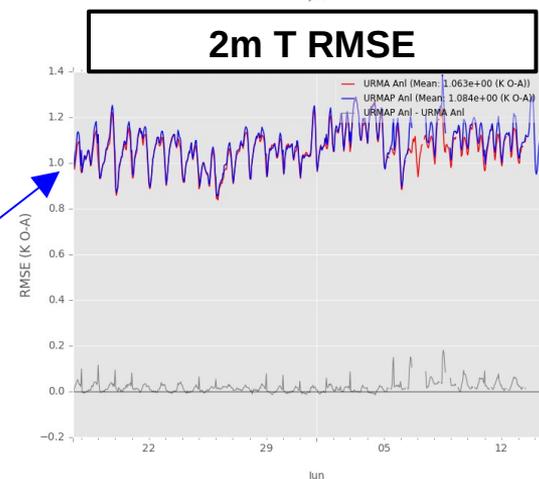
Ops URMA Analysis
v2.6 URMA Analysis

v2.6 Bundle: Bugfix for ceiling background

- Bug fix in RAP/HRRR SmartInit code for Ceiling

- GRIB2 Precision issue

- Will be fixed in RAP/HRRR SmartInit implemented along with v2.6 RTMA/URMA upgrade

Ops Ceiling Analysis

v2.6 Ceiling Analysis
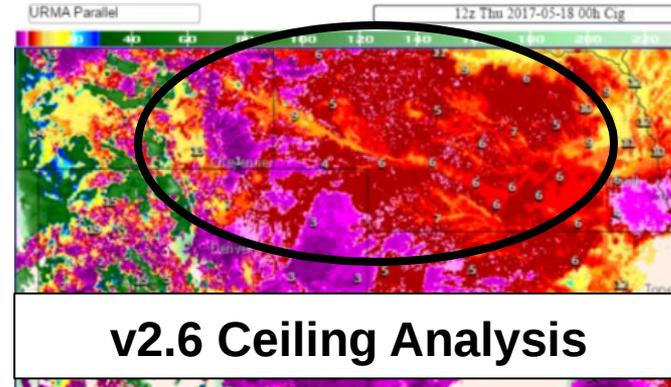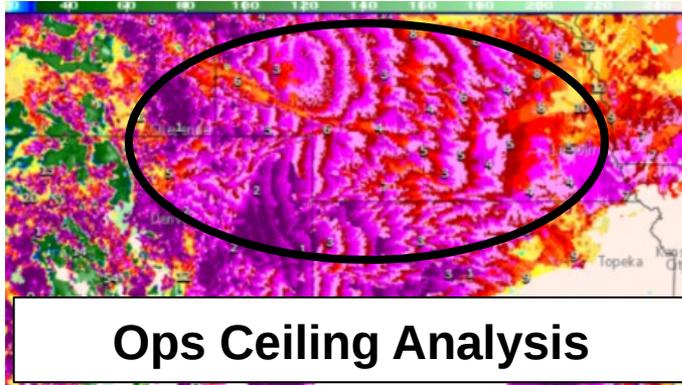
V2.6 Bundle: Coastline background error change

- Artifacts noted around Great Salt Lake (provided by Darren Van Cleave on Jan. 9)
- Refresher:
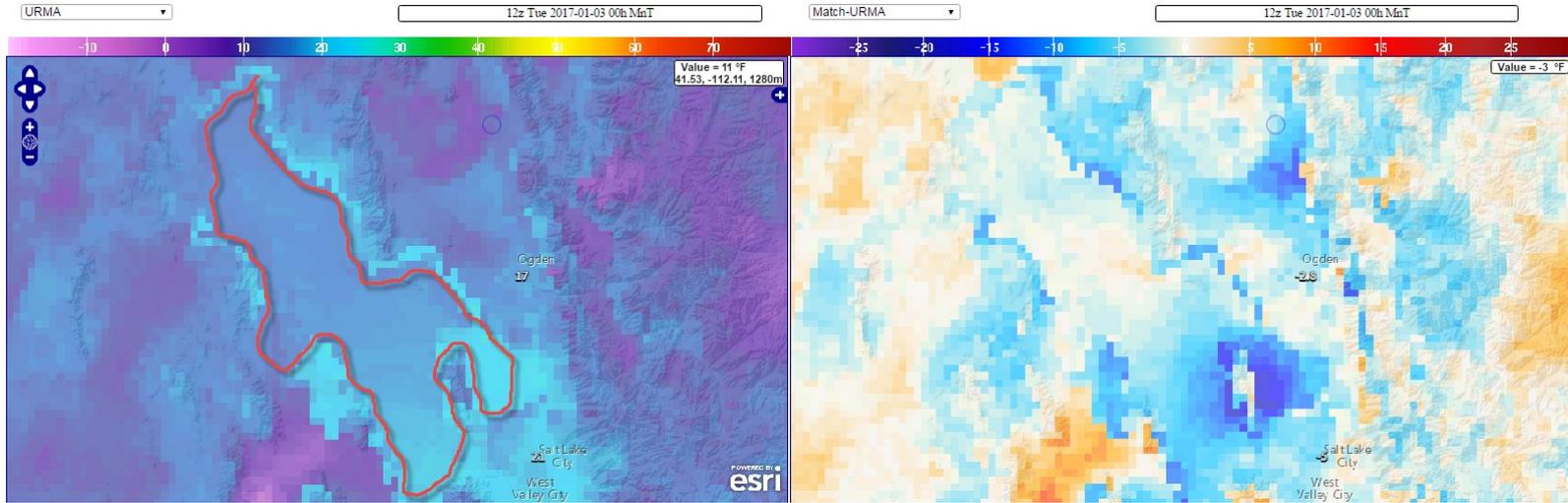
Initial impression: Likely a mismatch between terrain and land/sea mask data sets

After getting the terrain updates for v2.6 we re-checked the issue - but it remained!

v2.6 Bundle: Coastline background error change

- Further investigation revealed it is an issue with how we analyze temperature across water and land boundaries

    ○ RTMA/URMA steepens the coastlines to retain land/water contrasts

        ■ Effectively sharpens the background error covariance

No steepening
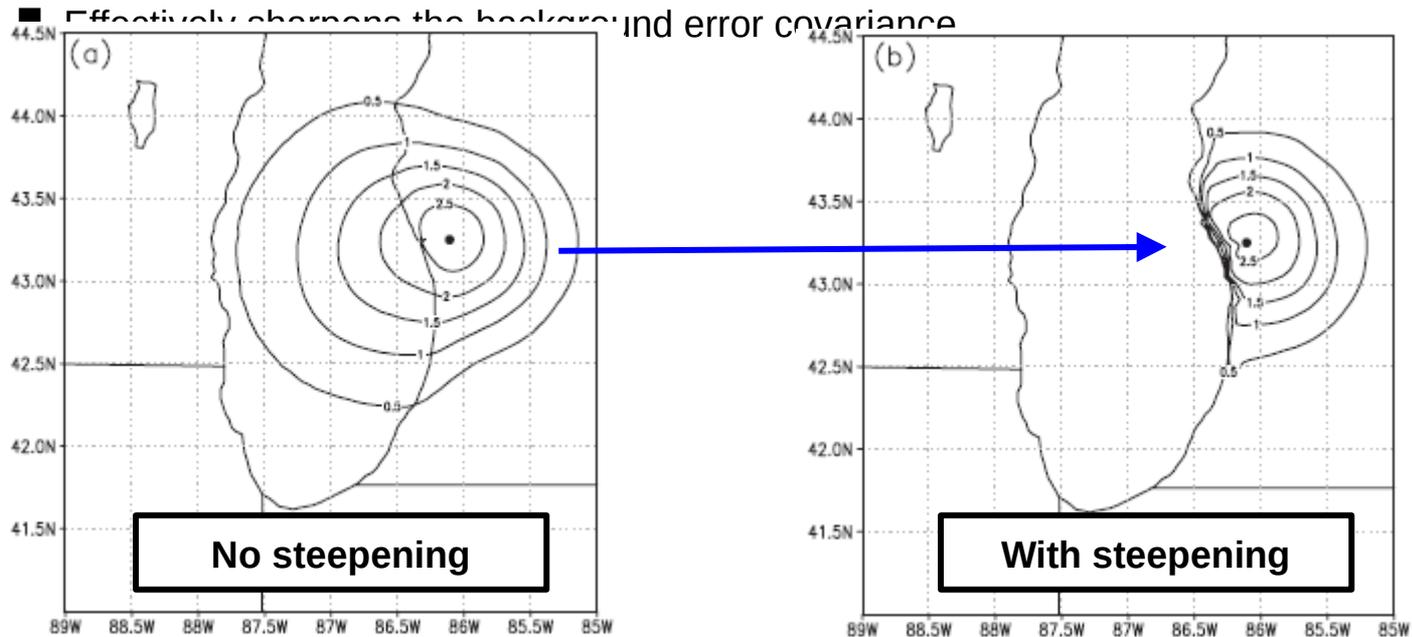
With steepening

v2.6 Bundle: Coastline background error change

- This steepening is overdone and leading to artifacts

An artifact in Ops URMA

CTL 2m T
20170416 12Z cycle F00 hrs Valid 20170416 12Z

CTL Analysis Inc 2m T
20170416 12Z cycle F00 hrs Valid 20170416 12Z

Note the ring around the lake in the analysis increments
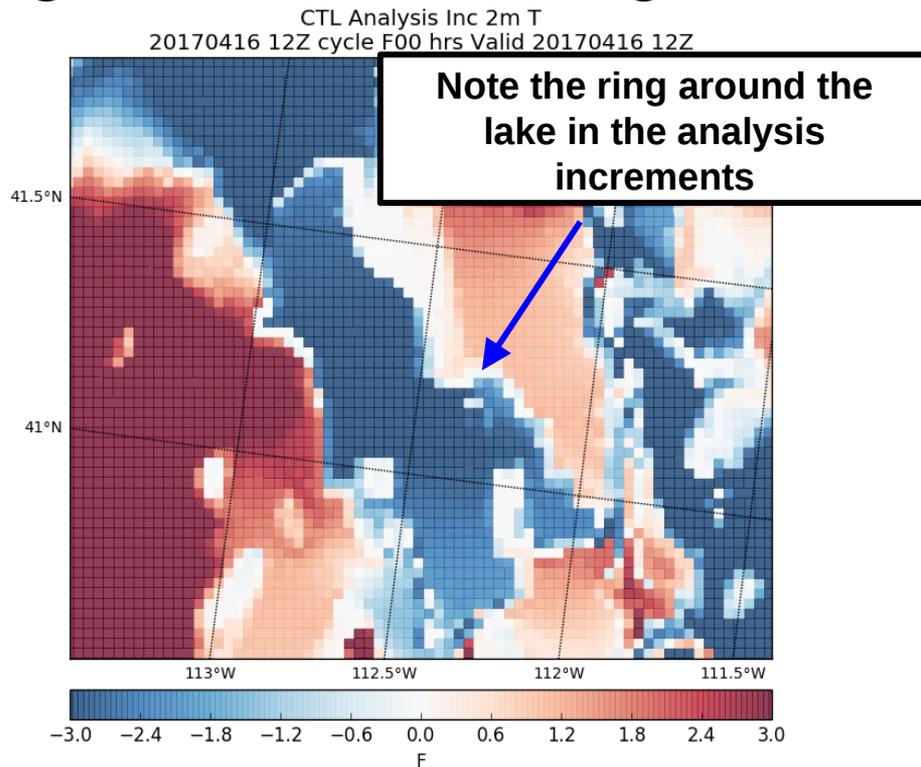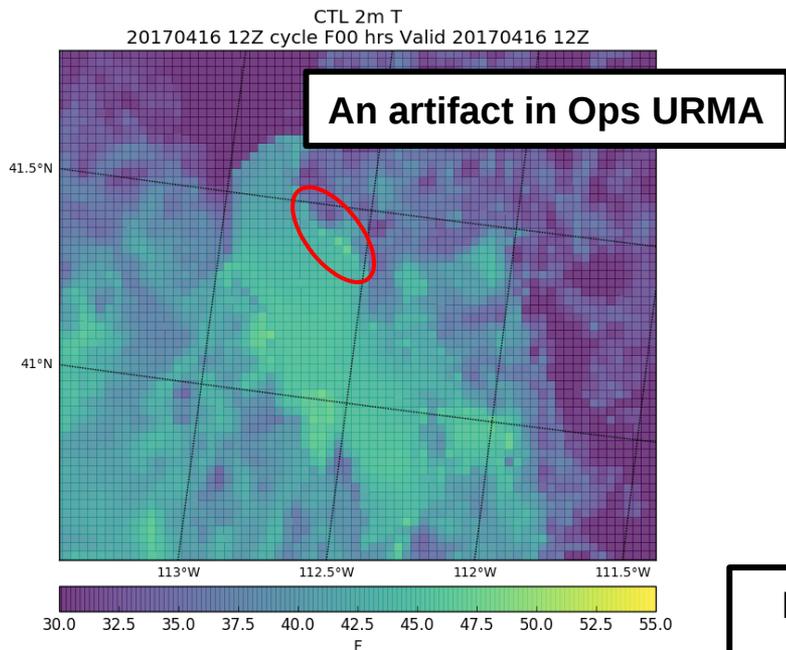
In this "ring" the background is not being updated - which leads to the artifacts

v2.6 Bundle: Coastline background error change

- Solution is to reduce the steepening

Para 2m T
20170416 12Z cycle F00 hrs Valid 20170416 12Z

Artifact around lake improved

Para Analysis Inc 2m T
20170416 12Z cycle F00 hrs Valid 20170416 12Z

Increments now spread across coastline - more diffuse
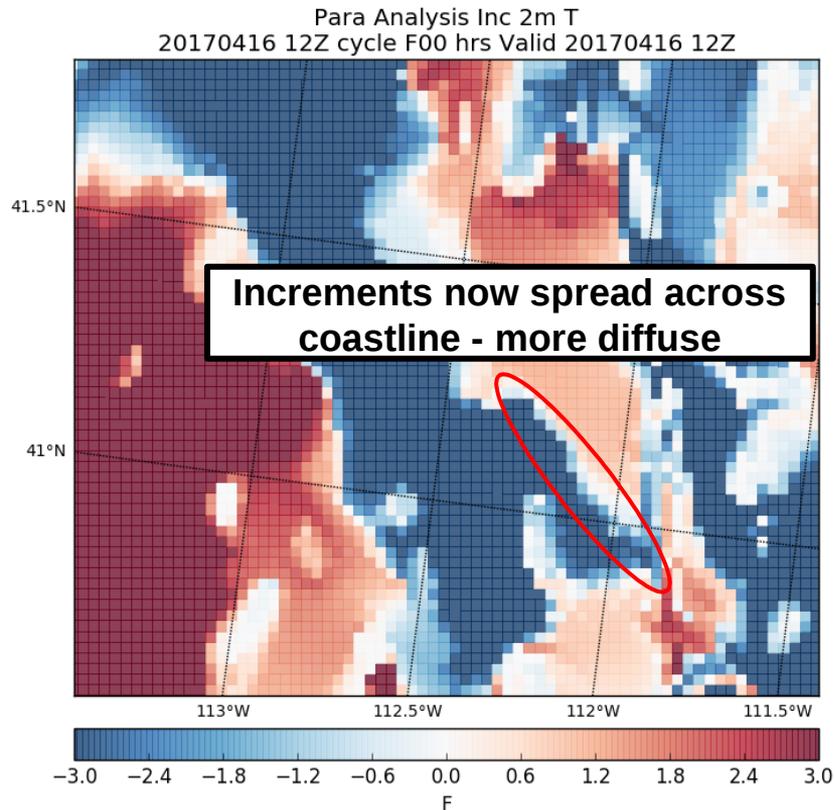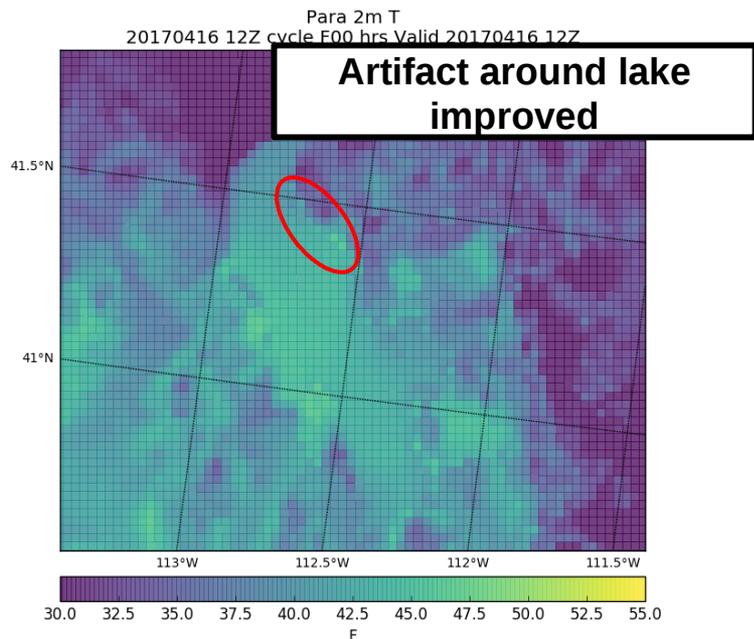
v2.6 Bundle: Coastline background error change

- Further investigation showed RTMA/URMA had this issue around many coastlines.

Example: Central Florida Panhandle

An artifact in Ops URMA

Artifact is gone in v2.6 URMA
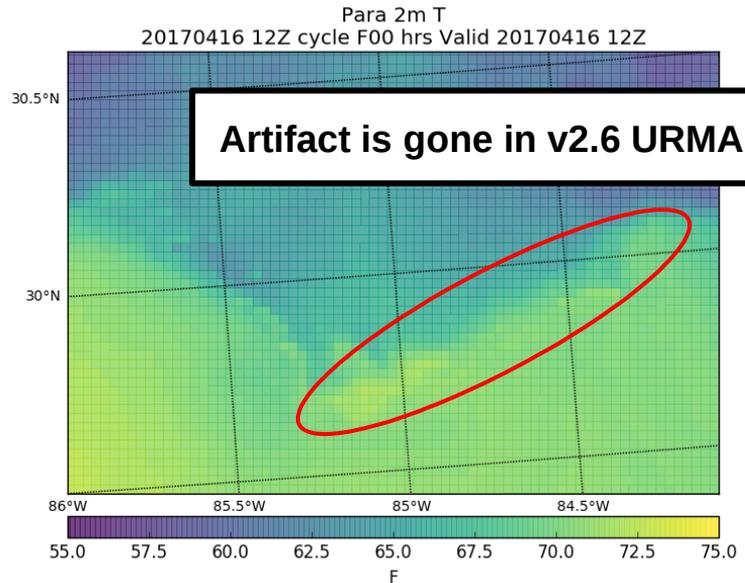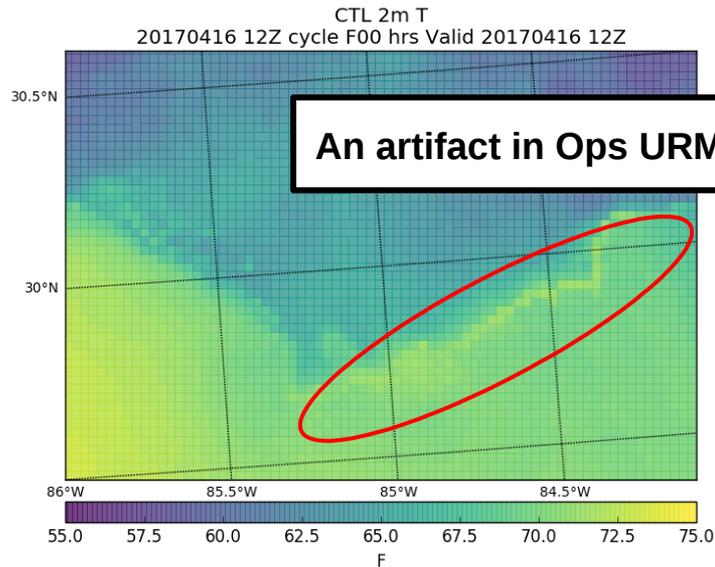
Thanks to Darren Van Cleave for bringing this (tricky!) issue to our attention!

v2.6 Bundle: GLERL Method over Great Lakes

- Goal: Create a smooth wind analysis over the Great Lakes that can be used to initialize Great Lakes Wave model

- MMAB (Henrique Alves) suggested that URMA try to mimic analysis produced at GLERL.

- Analysis relies on additional 'adjusted' observations.

  - Selected land-based sites used

  - Formula developed at GLERL to adjust observations to represent over-water conditions

  - Adjusted obs are then placed over the lake, terrain escarpment prevents cross-contamination

  - Original ob remains at original site

  - Additional ob sites were relocated so their location was consistent with land/sea mask

- Adjustments are made in a new subroutine in observation file

GLERL Ob Adjustments

Ob with adjusted value is placed in the water
Same distance + increment from shore

KCLE (adj water)

KBKL (adj water)

OH153 (orig)

CNDO1 (orig)

Increment for obs along coast

3.5 km

KBKL (orig)

E8077 (orig)

9.5 km

XCLE (orig)

WEWST (orig)

XCLE (moved land ob)

T050 (orig)

C8332 (orig)

D5616 (orig)

OH151 (orig)

7.5 km

Relocate land ob according to land mask

E4532 (orig)

D8454 (orig)

KCLE (orig)

Original selected ob

Google earth

Image © 2016 TerraMetrics
Image NOAA

10 km

Wind Speed Differences
Dev - Prod (kts)
6/18/17 12Z

Legend
-105.542 to -5
-2 to -1
-3 to -2
-4 to -3
-5 to -4
1 to 2
2 to 3
3 to 4

Observations:
Original
Moved over land
Moved over water
Adjusted l->w

Google earth

Image NOAA
© 2017 Google
Image Landsat / Copernicus

100 km
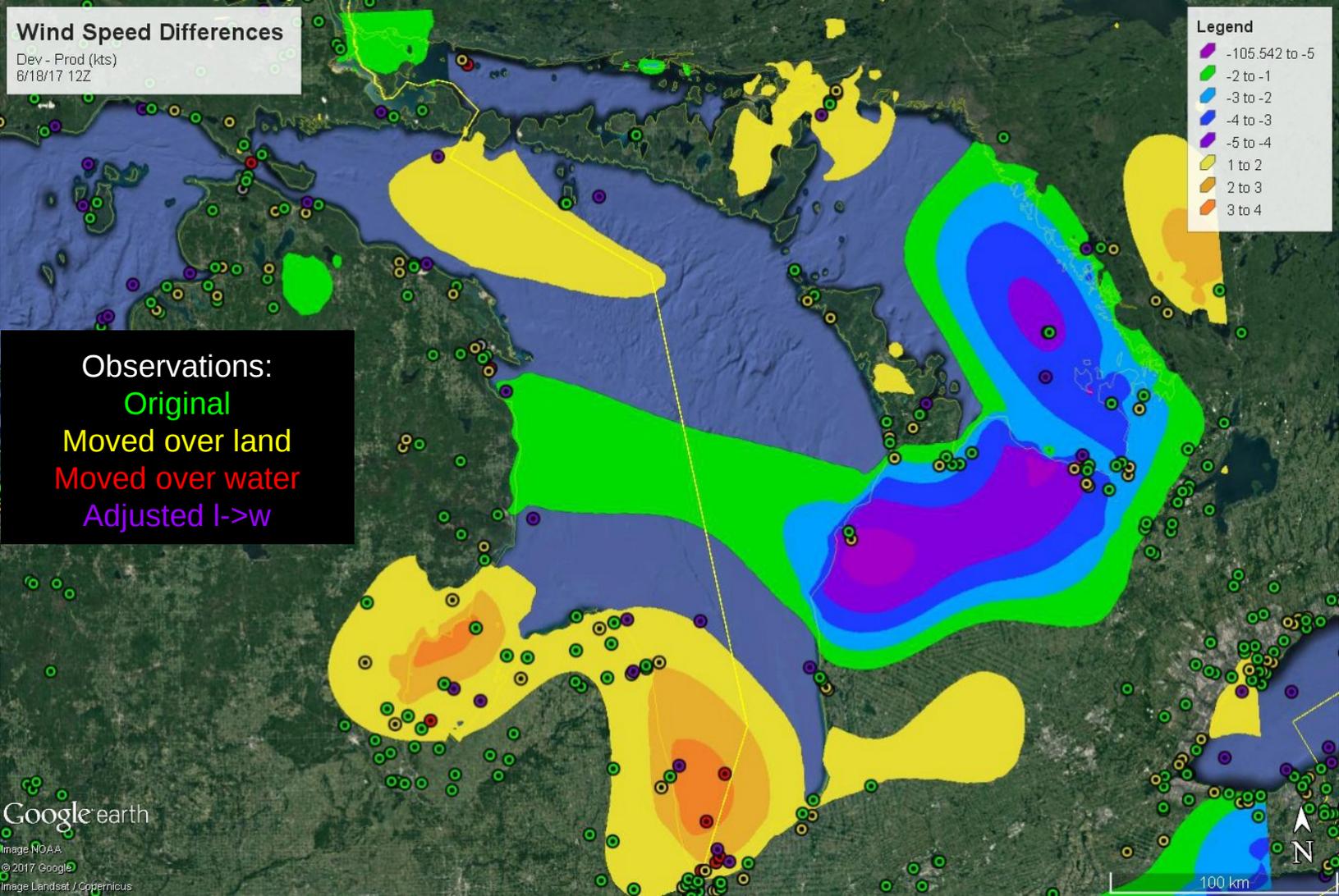
Evaluations - Part 1

- MDL: Recommends implementation

  - New wave height and min/max RH helpful for NBM

  - Hourly precip is helpful for the blend

- Alaska Region: Recommends implementation

  - Will continue evaluating new ceiling

  - New AK NAM nest is improving surface T

- Southern Region: Recommends implementation

    - Like the RU-RTMA, some forecasters have noted analyses improvements at and near the coast, URMA significant wave height will help with verification and validation of some marine forecasts, hourly precipitation fields will provide beneficial record for post-event studies of excessive rainfall events.

- Western Region:

Evaluations - Part 2

- Eastern Region: Recommends implementation

  - RU-RTMA not yet beneficial until dissemination to WFOs is addressed (data is available on ftp)

  - Great Lakes

    - Wind: seems a bit better, but difficult to tell.

    - Temp: parallel is warmer, potentially degraded (coastline steepening change?)

      - [EMC also addressed a bug in the GLERL temp adjustment that would cause warm temps]

  - Dissemination issues during eval

  - Hourly precip is helpful and new terrain may be improving analysis

- OPC: Provided informal feedback - No recommendation

  - Prefer more extensive coverage of the wave height analysis beyond CONUS

Evaluations - Part 3

- AWC: Recommends implementation

  - Noted trouble with dev-machine related latency on RU-RTMA

  - "The addition of the 15-min RURTMA is critical for our users from an aviation perspective. This product is very consistent with the hourly product yet has greatly reduced latency."

- WPC: Recommends implementation

  - Mostly evaluated temperature and moisture

  - Temps over Great Lakes were sometimes 2-4 F warmer (coastline steepening change + GLERL obs)

- FAA: Provided informal feedback and recommends implementation

  - Differences noticed in cloud amount and ceiling

  - Parallel had less restrictive ceilings and more gradual transition between flight categories

What's next? v2.7

- Updated background error covariance - better fit to observations

    ○ Good enough item: 3

    ○ Significant change

    ○ May extend to analysis uncertainty (Good enough item 4)

- Improve C&V analysis via changing the variable transformation approach in the analysis algorithm

    ○ Better fit to the observations

- Update terrain and land/sea mask for AK

- Introduce provider-specific observation errors

    ○ Good enough item 3b (also helps with item 2)

- RU-RTMA latency to 15 mins

Thanks! Questions about v2.6, future developments, etc.?:
rtma.feedback.vlab@noaa.gov

BACKUP SLIDES

# Ahead to v2.7: Improving the Background Error Model

- Improved background error covariance model
  - Will fit data closer, **good enough item 3a/d**
  - Testing is in progress. Will broadcast a test parallel to the field as soon as possible.
  - When the background deviates considerably from an observation the analysis struggles to fit the observation well
    - Decreasing the observation error can help - but it's not the observation that is in error
    - *Increasing* the background error will guide the analysis to fit the data more closely

Looking Ahead to v2.7: Updated background error

Medford, Oregon

Control: Temperature Analysis Increments

Experiment: Temperature Analysis Increments
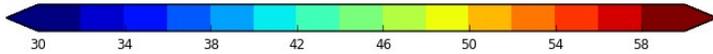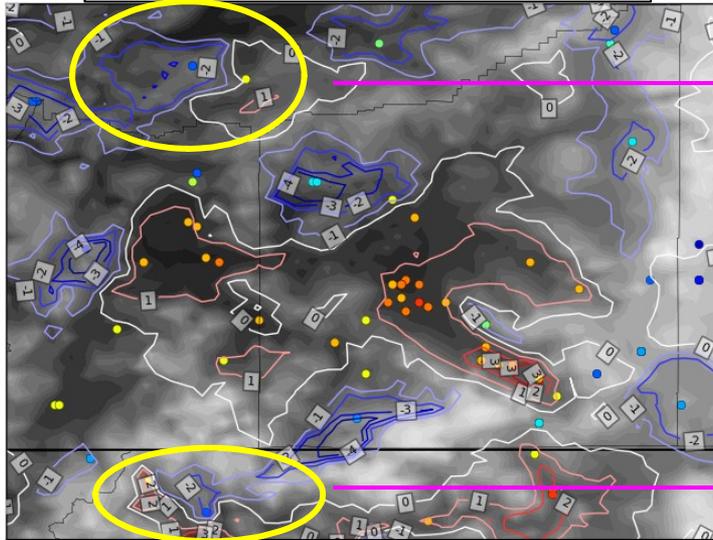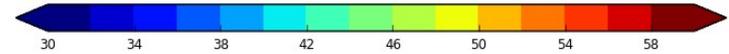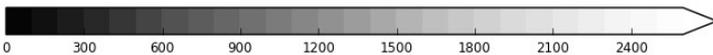
With updated background error covariance model EXP is able to more closely fit the observations

Looking Ahead to v2.7: Updated background error

Medford, Oregon

Control Temperature Analysis

Experiment Temperature Analysis
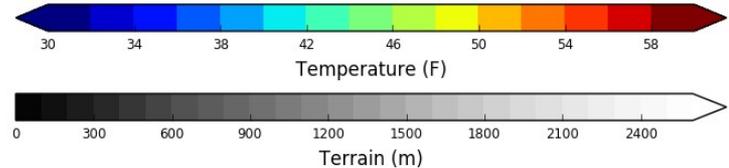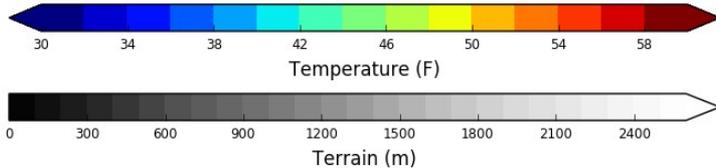
With updated background error covariance model EXP is able to more closely fit the observations

Looking Ahead to v2.7

- EXP shows closer fit to observations over CTL
- Current test revises the background error based upon terrain variability in a neighborhood of a gridpoint
- Expandable to the variability in the field of interest
  - May improve utility of estimate of analysis error by providing some flow-dependence
- More testing is needed - field input will be critical
  - e.g., valley cold pool case studies

EXP-CTL Temperature Analysis
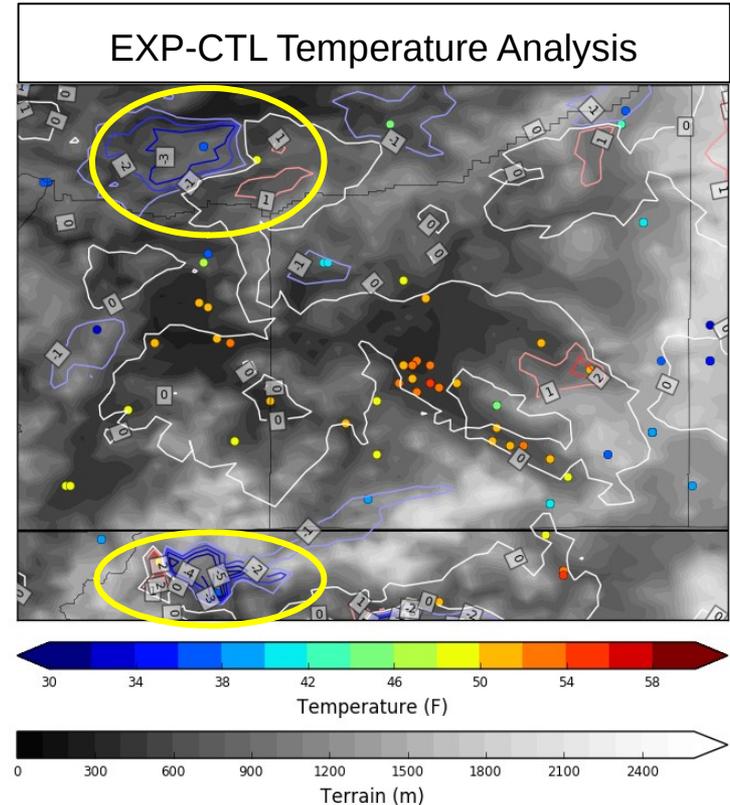
Mesonet QC Enhancements

- Enhanced QC requested in 'good enough' document (item 2B)

- Meeting with stakeholders (interested WR SOOs and ERH) held in April

- Created form that SOO/DOH/center can use to identify bad stations

  - Finding was that SOOs and DOHs should control this, not individual forecasters.

  - List of stations is entered on sharable spreadsheet for easy tracking

  - Form also approved by NCO (Carissa Klemmer/Patrick O'Reilly)

- We will investigate and flag via SDM's desk as needed

- Requires decoder RFC (BUFR table change to mesonets) to process SDM edit marks

Improving Data Latency

Max Possible Additional Obs From Updating Tanks Every Minute vs. Two Minutes (current)